Observations on the Life History and Bionomics of the Carp Minnow, *Oxygaster bacaila* (Hamilton)

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(*With three text-figures*)

Observations on the maturation, breeding season, sexual dimorphism, fecundity, induced breeding, life history, food and feeding habits of *Oxygaster bacaila* have been made and the data compared with the published information on allied species.

Introduction

Oxygaster bacaila is one of the medium sized species of the genus with its distribution 'throughout India except Malabar, Mysore, Madras and parts of Deccan' (Day 1878). It is common in ponds in Assam along with other 'weed' fishes like *O. phulo*, *Amblypharyngodon mola*, *Osteobrama cotio*, *Puntius* spp., *Ambassis ranga* and *Ambassis nama*. *O. bacaila* and allied species occur abundantly in all inland waters and constitute a minor fishery in some areas (Alikunhi & Chaudhuri 1954). Preliminary observations made at Cuttack on the culture of *O. bacaila* as a forage fish indicated that the total production, calculated per hectare, within a period of four and a half months was 187.7 kg. (Anon. 1955).

Information on the bionomics and life history of the genus *Oxygaster* is still scanty. The main contributions are the brief accounts on the food and feeding habits and development of *O. argentea* (Chacko *et al.* 1946), *O. untrahi* (Chacko 1951), the biology of *O. gora* (Sehgal & Singh 1962) and a paper on the bionomics and life history of *O. phulo* (Alikunhi & Chaudhuri 1954). In the present work, observations on the life history and some aspects of the bionomics of *O. bacaila* are reported.

Material and Methods

Monthly collections of the fish, to study the maturation, food and feeding habits, were made from the Government Fish Farm, Joysagar, and adjoining waters. The maturity stages were fixed following the 'Interna-

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tional scale' (Wood 1930). For fecundity studies, mature females preserved in formalin were measured and weighed, the weights of the ovaries recorded, the number of ova from two samples of one gramme each was counted and the total number of ova in each ovary was computed.

Mature fish were induced to breed in the laboratory by administration of carp pituitary hormones and the embryonic and larval developmental stages were studied. Ten specimens were measured to find out the average measurements of the larval and post-larval stages described.

To study the food and feeding habits of the fish, the fore-gut with stomach was dissected out and the contents transferred to a slide and examined under a microscope. The percentage composition of the different items was determined by 'eye estimation'.

Breeding Season

Maturation

The mature males ranged in length from 79 to 117 mm. and females, from 98 to 149 mm. The males appear to be slightly smaller in size than the females.

The gonads were stages II-III of maturity in January. By the end of February and early March, some of the males had attained the V stage and were oozing milt on gentle pressure, but the females were mostly in III-IV stages. During late March the majority of females were in IV stage, while stray ones were in V stage. Bulk of the females, however, were found to be fully mature by the end of April and early May. The spawning season appears to extend from last part of April to the end of July, the peak being in May and early June. No immature specimens were seen during the breeding season, indicating that the fish matures during the first year. Periodical examination of the spent fish showed that the gonads remained quiescent during the rest of the season, suggesting that the fish breeds only once during the year.

Sexual dimorphism

The sexes in *O. bacaila* can be easily distinguished during the breeding season by the coloration of the body and the fins as follows :

Distinguishing characters	♂	♀
1. The lateral band on the body above the lateral line ..	less conspicuous	conspicuous and darker
2. Dorsal body coloration ..	pale green	darker
3. Ventral fins ..	pale yellow	white
4. Anal fin ..	pale yellow	white

Fecundity

The ripe ovary is pale grey in colour with ova of almost uniform size. The fully ripe ovum is translucent, nearly spherical in shape, with a diameter ranging from 0·612 to 0·663 mm.

The fecundity of eleven specimens ranging in length from 113 to 138 mm. was studied and the data are given in Table 1. The total number of ova ranged from 14,663 to 29,925.

TABLE 1

FECUNDITY DATA OF *O. bacaila*

Total length (mm.)	Total weight (gm.)	Weight of ovary (gm.)	Total No. of ova	No. of ova per gm. body weight	No. of ova per gm. ovary	Stage of ovary	Size of ova (mm.)
113	12·75	2·61	14,663	1,150	5,618	IV	0·510
113	14·75	3·80	16,956	1,136	4,462	IV	0·544
115	13·50	2·83	16,379	1,213	5,788	IV	0·510
117	16·75	4·20	17,917	1,069	4,266	V	0·663
120	16·50	3·16	17,904	1,058	5,666	IV	0·510
122	18·25	4·61	23,050	1,263	5,000	V	0·612
123	21·00	5·28	22,207	1,057	4,230	V	0·629
124	18·00	5·22	26,465	1,470	5,070	V	0·646
126	21·50	5·94	25,898	1,204	4,360	V	0·612
129	20·50	5·41	29,051	1,417	5,370	IV	0·527
138	22·50	6·30	29,925	1,330	4,750	V	0·663

It is seen that the fecundity increases with the increase in size of the fish. The number of ova per gramme weight of ovary ranged from 4,230 to 5,788. The number of ova per gramme body weight or the 'fecundity factor' ranged from 1,057 to 1,470 with an average of 1,219.

INDUCED BREEDING

A preliminary dose of 2 to 4 mg. of heteroplastic pituitary gland per kg. weight of the fish, followed, after four to six hours, by a second dose of 8 to 10 mg. per kg. was administered to the female and a single injection of 2 to 4 mg. per kg. was given to the male at the time of second injection for the female. The commencement of spawning is marked by active, excited movement of the breeders, the female being chased by the males. The process of spawning is intermittent and is completed in about thirty minutes.

As the eggs were observed to be adhesive, submerged aquatic weeds like *Najas*, *Ceratophyllum* and *Hydrilla* were provided as egg-collectors.

Embryonic Development

The adhesive eggs are spherical and demersal, when detached. In ponds, they were attached to submerged aquatic weeds and grasses or the bottom soil in shallow areas. The eggs are translucent and slightly greyish in colour when just laid. They swell up uniformly in fifteen to twenty minutes and become transparent. The fully swollen eggs have a fairly large perivitelline space and measure as follows :

	Range (mm.)	Average (mm.)
Diameter of outer shell ..	1·190-1·309	1·241
Diameter of egg proper ..	0·663-0·697	0·680

Cleavage (Text-fig. 1, *a-d*) : About twenty minutes after fertilisation, a crescentic, narrow blastodisc appears over one end of the yolk mass. The first cleavage occurs about thirty-three minutes after fertilisation. The second cleavage takes place seven minutes later, which is followed by the eight celled stage in the next six to seven minutes. The fourth cleavage occurs about fifty-two minutes after fertilisation and the thirty-two-celled stage follows in another four minutes. The morula cap is formed in one hour and seventeen minutes after fertilisation.

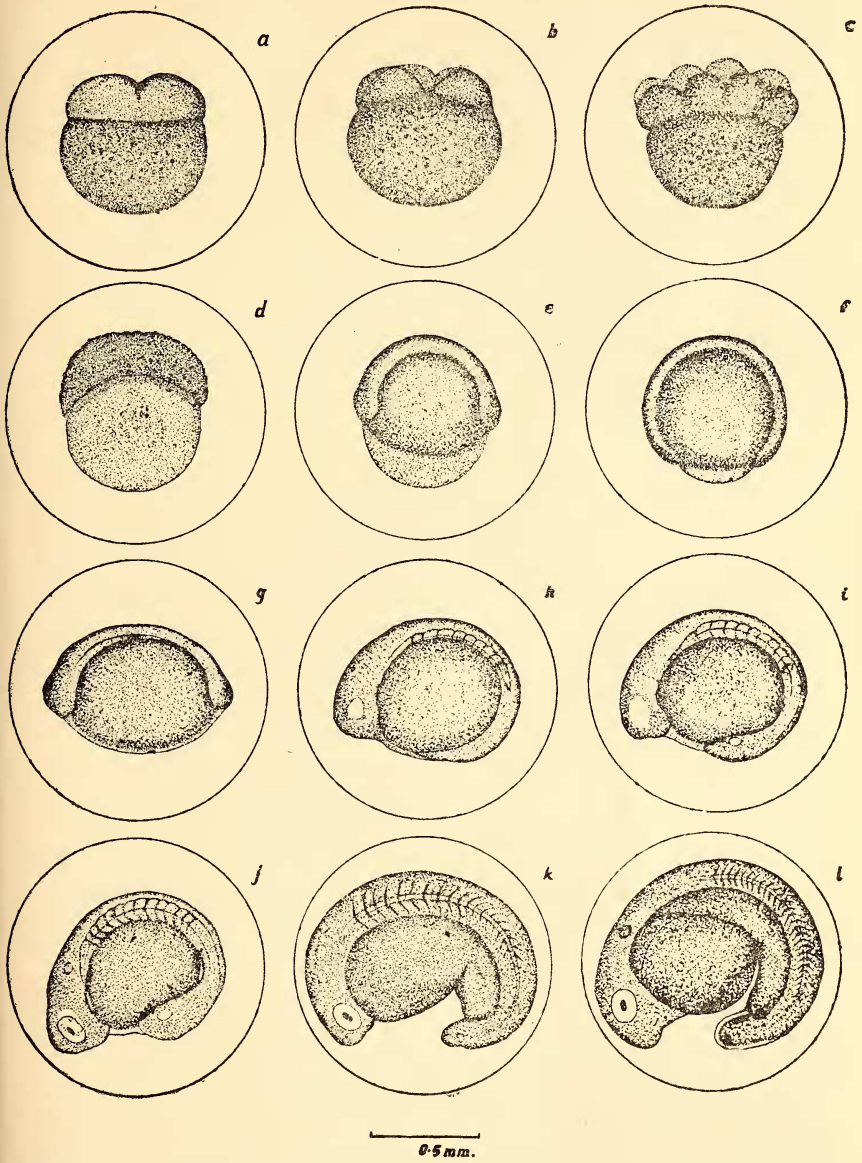
Differentiation of the embryo (Text-fig. 1, *e-l*) : The blastoderm cells begin to spread over the yolk mass, about a third of which is covered in another two hours. The yolk-plug stage is reached in about four hours and twenty-seven minutes after fertilisation. The yolk is completely invaginated by the blastoderm cells in the next twenty minutes and the embryonic rudiment is formed as a marginal, narrow, thickened band.

The embryo now starts elongation and when five hours and twenty minutes' old, measures 0·969×0·663 mm. The cephalic and caudal ends are now faintly discernible. The notochord has formed and two myotomes have appeared. In the next thirty minutes the cephalic and caudal ends become further differentiated and easily distinguishable and another two myotomes have been added.

The cephalic region becomes more prominent when the embryo is six hours and forty-five minutes' old. The rudiments of the optic vesicles have formed. Altogether, eight or nine myotomes have differentiated. About ten minutes later, the Kupffer's vesicle appears as an oval area in the caudal region.

In a seven hours and twenty minutes' old embryo the lens appears in the optic vesicles. About twelve to thirteen myotomes can be counted. The embryonic fin-fold appears around the elongated caudal end and its tip becomes free from the yolk mass. In another thirty minutes the yolk elongates and three more myotomes are added. The otoliths

appear as two minute concretions in each otic vesicle. The embryo makes occasional twitching movements.



Text-fig. 1. Embryonic development of *Oxygaster bacaila* (Hamilton)

Fertilised egg (*a*) Two-celled stage, (*b*) Four-celled stage, (*c*) Eight-celled stage, (*d*) Morula stage, (*e*) Early gastrulation, (*f*) Yolk-plug stage; Embryo, (*g*) 5-50 hours old, (*h*) 6-45 hours old, (*i*) 6-55 hours old, (*j*) 7-20 hours old, (*k*) 8-00 hours old, (*l*) 10-00 hours old.

The Kupffer's vesicle becomes reduced in size in the eight hours' old embryo. The yolk becomes elongated and tapering. More myotomes differentiate. The embryo becomes longer and measures 1·394 mm. in length. It frequently moves and changes its position inside the egg shell.

Ten hours' old embryo has further elongated and it executes vigorous movements and almost fills up the entire perivitelline space. The heart pulsates. About twenty-four to twenty-six myotomes can be discerned. Kupffer's vesicle has disappeared. The anus is indicated. In the next four hours, ten to twelve myotomes are added and the embryos are ready for hatching. It takes about thirty minutes to one hour for the whole brood of eggs to hatch out.

At a water temperature range of 25·5 to 27·6°C, the period of incubation is fourteen to fourteen-and-a-half hours.

The larval and post-larval stages were reared in laboratory aquaria to study the subsequent differentiation of structures.

Larval Development

(Text-fig. 2, *a-c*)

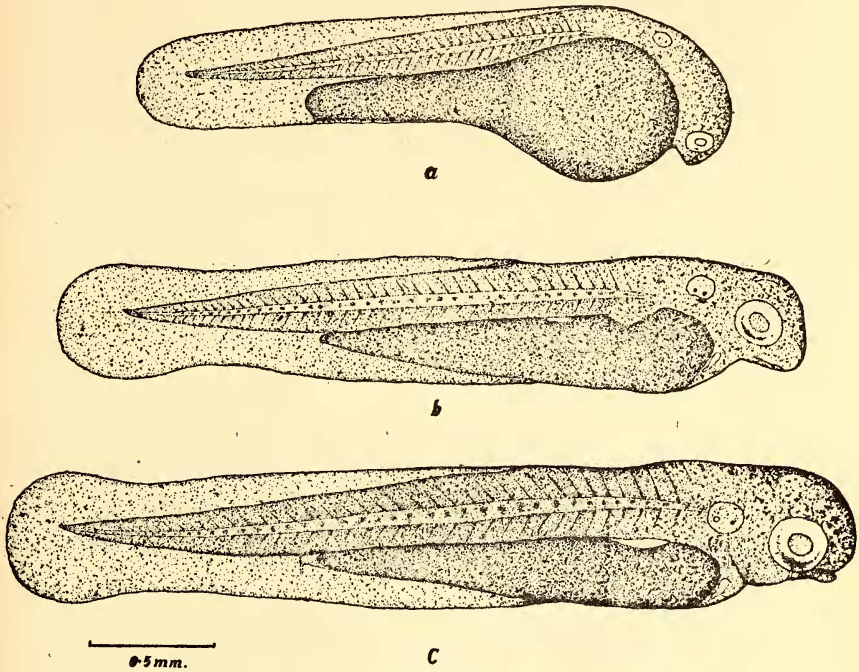
Larva, just after hatching : The hatchling is slender, small, almost transparent and without mouth, pectoral fins and body pigmentation, excepting for a small dark spot on the ventral aspect of the eye. The otic vesicles are oval in shape and the concretions inside them are of almost same size. The embryonic fin-fold extends up to about two-thirds of the body. It is broader around the caudal end and extends ventrally beyond the vent, up to the middle of the body. The anus is situated far back and the post-anal length is about one-fourth the total length. There are about thirty-seven to thirty-eight myotomes, of which twenty-seven are pre-anal in position. The yolk-sac is broad anteriorly and tapers towards the vent. The larva lies quiescent on its side in the bottom and occasionally moves about for some time.

Larva, twelve hours after hatching : The buccal invagination is indicated. The pectoral fin buds and the rudiment of the swim-bladder have formed. The otic vesicles become rounded.

Larva, twenty-four hours after hatching : The yolk-sac becomes thinner. The lower jaw is formed and the mouth is subterminal. Two to four melanophores appear on the head. The pectoral fins become flap-like and the larva freely swims about in water. The otic vesicles become more rounded and of the two concretions inside, the posterior one becomes slightly larger in size.

Larva, forty-eight hours after hatching : Twelve to fifteen melanophores appear on the head. A line of melanophores forms just above

the yolk-sac, extending up to the caudal peduncle. The eyes are fully pigmented. The swim-bladder enlarges in size. The yolk-sac becomes very thin and ceratotrichia appear in the caudal fin.



Text-fig. 2. Larval stages of *Oxygaster bacaila* (Hamilton)
Larva (*a*) Just hatched out, (*b*) 12 hours old, (*c*) 24 hours old.

The average body measurements of the different larval stages described are given in Table 2.

TABLE 2

BODY MEASUREMENTS OF THE LARVAL STAGES DESCRIBED

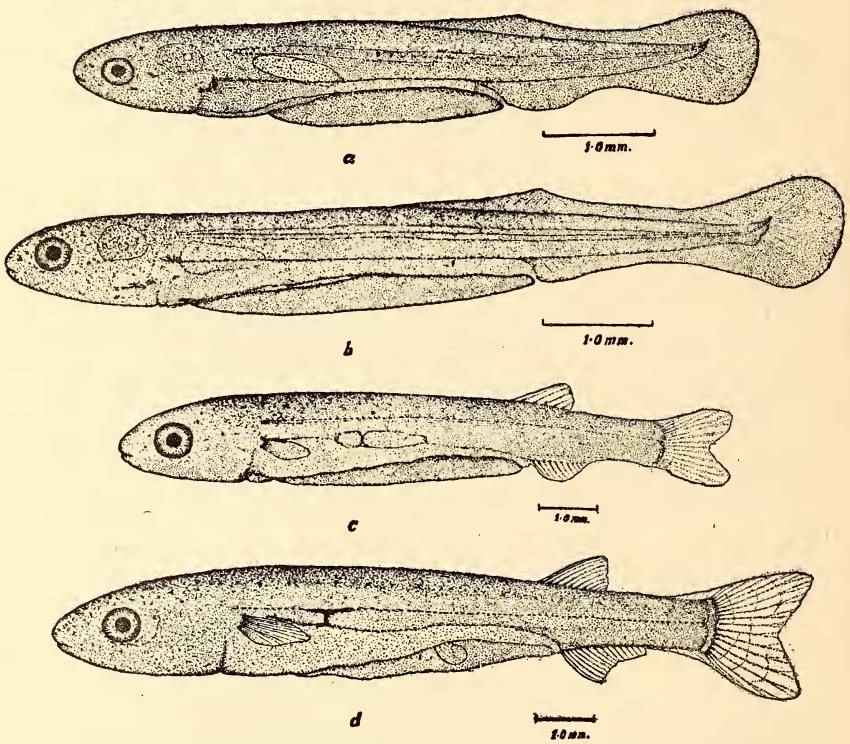
Average measurements of body parts in mm.	*Age in hours after hatching*			
	0*	12	24	48
Total length	2·482	3·111	3·519	3·970
Post-anal length of body ..	0·578	1·058	1·165	1·271
Maximum height of body ..	0·714	0·544	0·527	0·476
Length of yolk-sac	1·598	1·962	1·751	1·630
Maximum height of yolk-sac ..	0·680	0·323	0·255	0·187

* Just hatched

Post-Larval Development

(Text-fig. 3, *a-d*)

Post-larva, two-and-a-half days' old (4·267 *mm. in length*) : The yolk is completely absorbed and the larva starts to feed. The alimentary canal is straight. The number of melanophores has increased on the head. In addition to the line of melanophores on the ventral aspect of the myotomes, another line appears on the middle, each myotome having one melanophore. In the otic vesicle, the posterior concretion is about double the size of the anterior one. The larval fin-fold is continuous.



Text-fig. 3. Post-larval stages of *Oxygaster bacaila* (Hamilton)

Post-larva (*a*) 5·988 mm. in length, (*b*) 7.330 mm. in length, (*c*) 10·495 mm. in length, (*d*) 12·910 mm. in length.

Post-larva, four days' old (5·998 *mm. in length*): The embryonic dorsal fin-fold broadens at a level slightly posterior to the vent, indicating the formation of the dorsal fin. A similar broadening of the ventral fin-fold, posterior to the vent, indicates the position of the anal fin. The tip of the notochord is slightly upturned. The hypurals form as thickenings of the caudal fin and the rays are faintly indicated. More melanophores appear all over the body. The mouth becomes terminal and

slightly upturned. The larva becomes opaque and the internal structures are not visible.

Post-larva, six days' old (7·330 *mm. in length*) : The body pigmentation has further accentuated. The dorsal and anal fins are still continuous with the larval fin-fold and four rays can be discerned in each. In the caudal fin, which is rounded, about twelve rays appear.

Post-larva, nine days' old (10·495 *mm. in length*) : The full compliment of rays form in the pectoral fins. In the slightly forked caudal fin, seventeen rays have appeared. The dorsal fin is almost free from the larval fin-fold and has four to five rays. The anal fin is continuous with the ventral fin-fold posteriorly and has nine to ten rays.

Post-larva, eleven days' old (12·910 *mm. in length*) : The caudal fin rays have three articulations. The embryonic dorsal fin-fold, anterior to the caudal fin, has not atrophied fully. The dorsal fin has ten rays. The anal fin is free and has developed fourteen rays. Scales appear all over the body. The swim-bladder has constricted into two. Ventral fin buds form. The larva resembles the adult in general appearance.

Post-larva, fourteen days' old (16·910 *mm. in length*) : The full compliment of rays have formed in the anal and ventral fins. The pre-anal fin-fold is reduced in size. More melanophores appear all over the body.

Post-larva, seventeen days' old (20·640 *mm. in length*) : The pre-anal fin-fold completely disappears. The ventral fins acquire adult shape. The larva attains the form and shape of the adult in all details.

In Table 3, the average measurements of the different body parts of the larval stages described in the text are given.

Table 3

Average body measurements of the post-larval stages

Average measurements of body parts in mm.	*Age in days*						
	2½	4	6	9	11	14	17
Total length	4·267	5·998	7·330	10·495	12·910	16·910	20·640
Length of head	0·668	1·193	1·560	2·376	2·975	3·850	4·261
Post-anal length of body	1·395	2·059	2·630	3·488	3·990	6·670	8·490
Maximum height of body	0.519	0·716	0·925	1·372	1·877	2·286	2·830

Notes on Food and Feeding Habits

Smaller post-larvae (4 to 8 mm. in length ; reared in laboratory) fed mostly on small rotifers and phyto-plankters like *Microcystis*, *Anabaena*, *Euglena*, *Trachelomonas* and desmids. The larger post-larvae (9 to

20 mm. in length) and juveniles (21 to 40 mm. in length) fed mainly on zoo-plankters (67.4 per cent). Phytoplankters constituted the next important item (23·8 per cent) and the balance was made up by debris. The dominant groups of zoo-plankters encountered were rotifers (*Brachionus*, *Polyarthra*, *Keratella*, *Monostyla*, *Pedalia* and *Asplanchna*), cladocerans (*Moina*, *Bosmina* and *Ceriodaphnia*) and copepods (*Diaptomus*, *Cyclops*) and nauplii and phyto-plankters consisted of blue-green algae (*Microcystis*, *Anabaena* and *Oscillatoria*), green algae (*Cosmarium*, *Staurastrum*, *Arthrodesmus* and *Spirogyra*) and euglenoids (*Euglena*, *Phacus* and *Trachelomonas*). The phytoplankters encountered in the guts appear to have been consumed accidentally along with zoo-plankters and may not be of any food value to the fish as they pass through the gut without getting digested.

The adult fish (41 to 149 mm. in length) fed mainly on zoo-plankton (60·9 per cent) as was found in the case of larger post-larvae and juveniles. The other items found in the guts were filamentous algae (*Spirogyra*, *Anabaena* and *Oedogonium*, 19·2 per cent), aquatic insects (mostly small water bugs, 14·4 per cent) and some debris (5·5 per cent). Most of the guts examined were over '50 per cent full' to 'gorged' with food, empty guts being rarely encountered, indicating thereby that the feeding intensity of the fish is fairly high.

Discussion

Oxygaster bacaila is reported to attain a length of 178 mm. However, the largest specimen in the present collection measured only 149 mm.

O. bacaila, like the majority of 'weed' fishes, breeds in ponds in Assam from late April, almost with the onset of monsoon rains, and the breeding season extends till the middle of July. This is in contrast to that of *O. phulo* in Orissa, which is reported to have its peak spawning period just before the monsoon season (Alikunhi & Chaudhuri 1954). According to Qasim & Qayyum (1962), in northern India the breeding season of *O. bacaila* is from June to September and the peak spawning is in August. Thus, the fish matures and breeds about two months ahead in Assam, compared to northern India. This is presumably due to the early onset of monsoon in Assam, where major carps also have been observed to become mature and breed from the end of March onwards (Parameswaran *et al.*, unpublished data).

Sexual dimorphism as observed in *O. bacaila*, described earlier, occurs in *O. phulo* (Alikunhi & Chaudhuri loc. cit.), *O. argentea* and *O. untrahi* (Chacko *et al.* 1946).

The ripe ovarian eggs of *O. bacaila* are larger in diameter than those of *O. phulo* and are comparable to those of *O. gora* (Alikunhi &

Chaudhuri loc. cit.). The ovarian eggs of *O. untrahi* (Chacko 1951) are larger than those of *O. bacaila*.

The 'fecundity factor' of *O. phulo* (calculated from Alikunhi & Chaudhuri loc. cit.) ranges from 689 to 1,062, the average being, 804·5. Comparatively, the fecundity of *O. bacaila* is high.

A comparison of the embryonic and larval stages of *O. bacaila* and *O. phulo* (Alikunhi & Chaudhuri loc. cit.) is of some interest. The fertilised eggs of *O. bacaila* are larger in size compared to those of *O. phulo*, which measure 0·675 to 0·727 mm. in outer diameter and 0·476 to 0·485 mm. in inner diameter. In both species the eggs are adhesive, spherical and transparent. The period of incubation of *O. phulo*, at a water temperature ranging from 29·3 to 33·3°C. is about twelve hours. In *O. bacaila* also the incubation period is almost same in this temperature range and the hatchlings are in the same stage of differentiation. However, the hatchlings of the two species can be distinguished by the smaller size (2·025 mm.) and the larger number of myotomes (42, of which 25 are pre-anal) in *O. phulo*. The post-larva of *O. phulo*, with all the structures fully formed, measures 16 to 17 mm. in length and is thus decidedly smaller when compared to the same stage in *O. bacaila*.

Alikunhi & Chaudhuri (loc. cit.) have stated that *O. phulo* 'generally subsists on a predominantly zoo-plankton diet but also feeds on non-planktonic bottom living forms like *Spirogyra*, aquatic insects etc., in the absence or paucity of zoo-plankton'. The same appears to be substantially true in the case of *O. bacaila* also. The slightly up-turned mouth also probably indicates the plankton feeding habit of the fish. The food habits of the species are at variance with those of *O. argentea*, which feeds on planktonic algae (Chacko *et al.*, loc. cit.) and *O. gora* which feeds mainly on fish (Sehgal & Singh 1962).

The present study indicates that, as observed by Alikunhi & Chaudhuri (1954), *O. bacaila* also competes for food with major carp fry in nurseries and its food habits are incompatible with those of *Catla catla* in the adult stage. Hence, careful eradication of the species from fish ponds is desirable for ensuring better growth of the cultivable stock in them.

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